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2020

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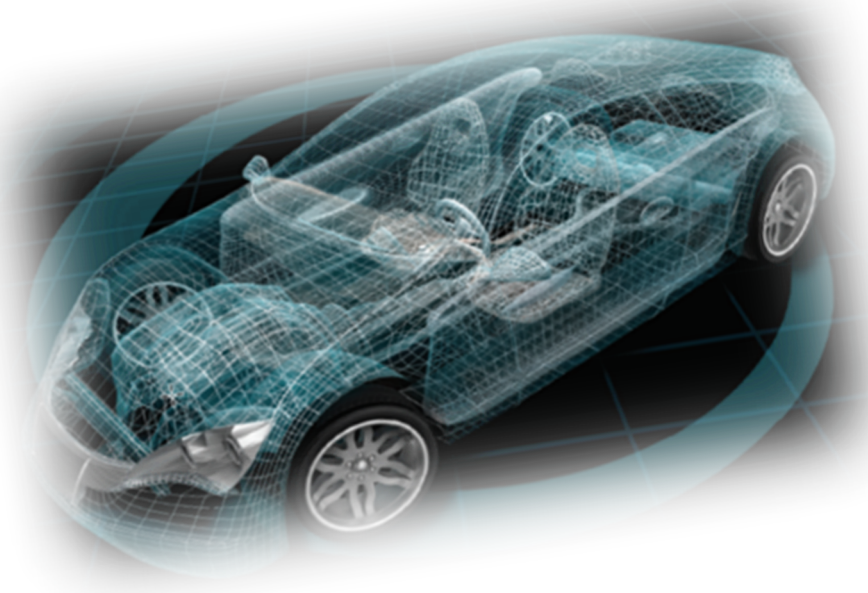
MIPI® A-PHY℠: Laying the Groundwork for MIPI's Automotive SerDes Solutions

MOBILE & BEYOND

Presentation Outline



MIPI A-PHY – System View

Ariel Lasry

Director, MIPI Alliance Board of Directors

MIPI A-PHY – Specification Overview

Edo Cohen

MIPI A-PHY Subgroup Vice-Lead

Q&A

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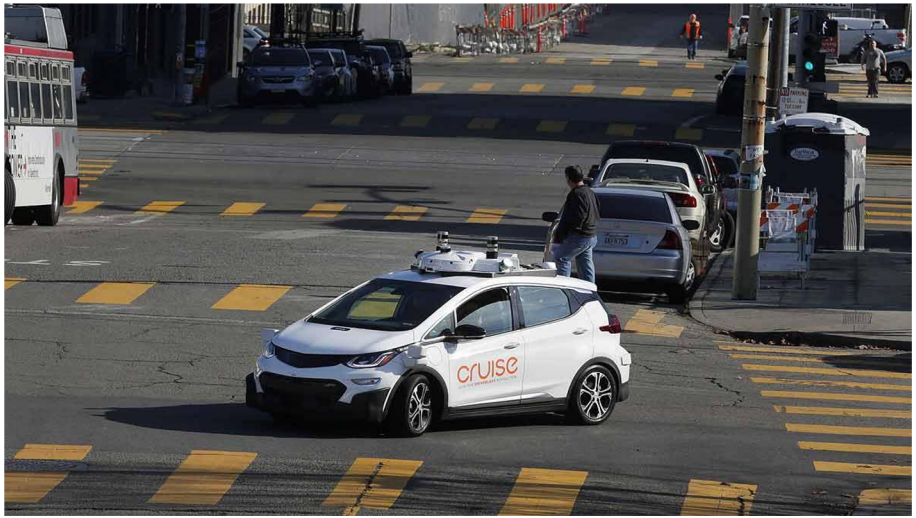
Auto Industry Transformation



Honda and GM Partner to Develop Mass Produced, Driverless Cars
Source: October 4, 2018, Automotive News

***CASE*:**
• Connected • Automated
• Shared • Electrified

- Connected: The move to 5G
- Automated: The move to L2/L2+ and beyond
- Shared: New OEMs, new business models, new alliances
- Electrified: Tesla and others

And . . .

Safety: Improved government safety regulations (FCWS, AEB, RVS, LDWS, etc.)
Fuel economy: Aggressive regulations

MIPI directly supports *CASE* via:
- Connected (MIPI RFFE^{SM}, others)
- Automated (MIPI A-PHY, MIPI CSI-2^{SM}, others)

RFFE: RF Front End
FCWS: Forward Collision Warning System **LDWS**: Lane Departure Warning System **AEB**: Autonomous Emergency Breaking **RVS**: Rear View System

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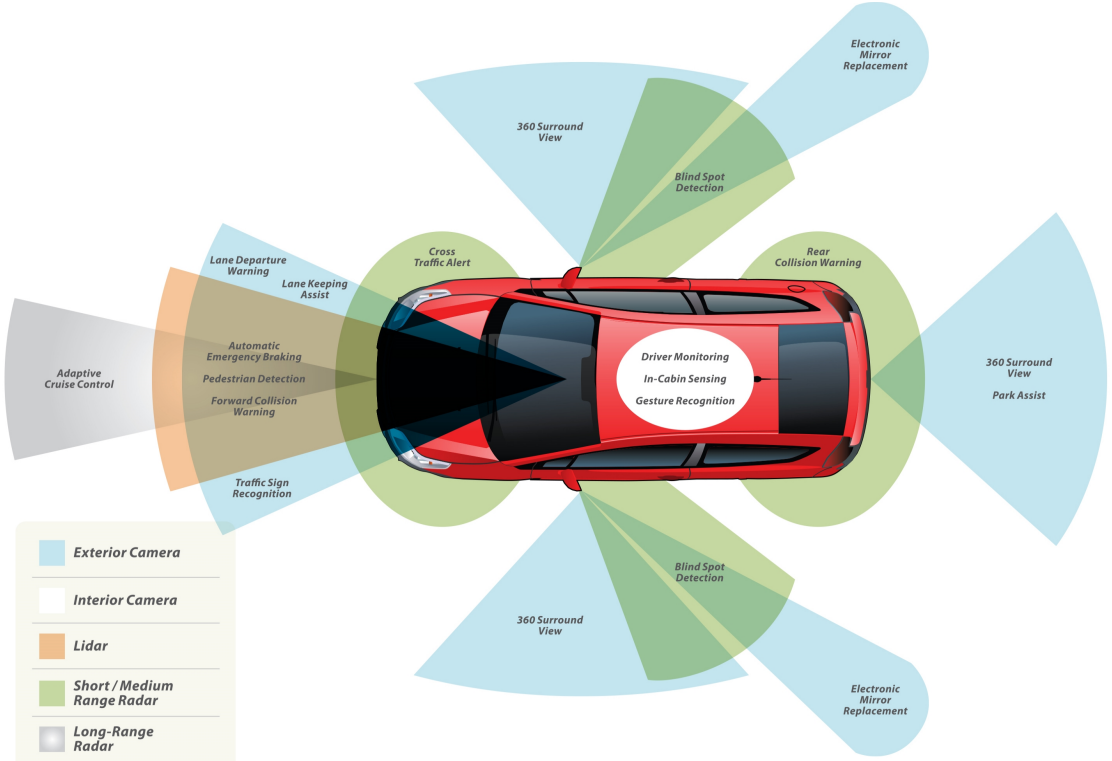
NCAP Regulations Driving Sensors & Display Adoption



- Worldwide NCAP ADAS and ADS standards driving adoption of multiple high data rate "surround sensors"
- Displays for driver viewing of assistance imaging and information also require

NCAP: New Car Assessment Program **ADAS**: Advanced Driver Assistance System **ADS**: Autonomous Driving System

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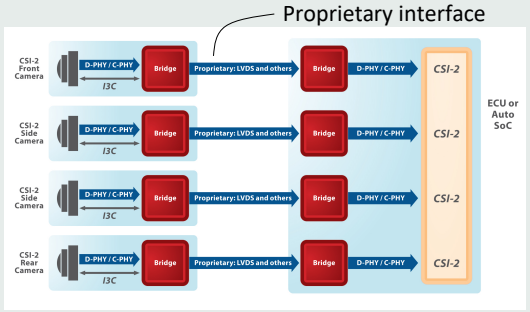
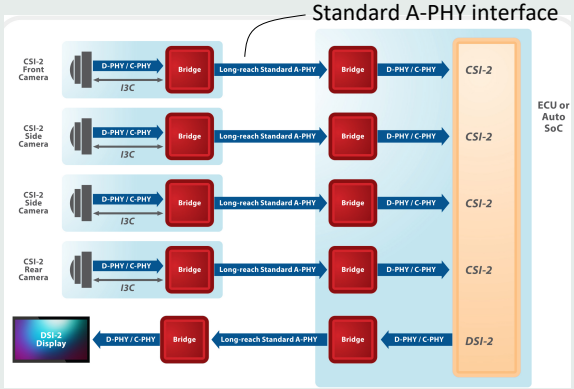
What is MIPI A-PHY?

- MIPI A-PHY is a physical layer specification targeted for ADAS/ADS surround sensor applications and Infotainment display applications in automotive. Version 1.0 will provide a 15-meter reach and data rates of 2-16 Gbps, with a roadmap to 24, 48 Gbps and beyond.
- MIPI A-PHY is the ONLY standard interface to support native camera (MIPI CSI-2SM) and display (MIPI DSI-2SM) interfaces for automotive. An adaptation layer is also being developed for VESA DisplayPort and eDP.

TODAY'S PROPRIETARY INTERFACE BRIDGE SOLUTIONS



TOMORROW A-PHY STANDARD INTERFACE BRIDGE SOLUTIONS



FUTURE INTEGRATED A-PHY
(NO BRIDGES: Lower cost, weight, power)

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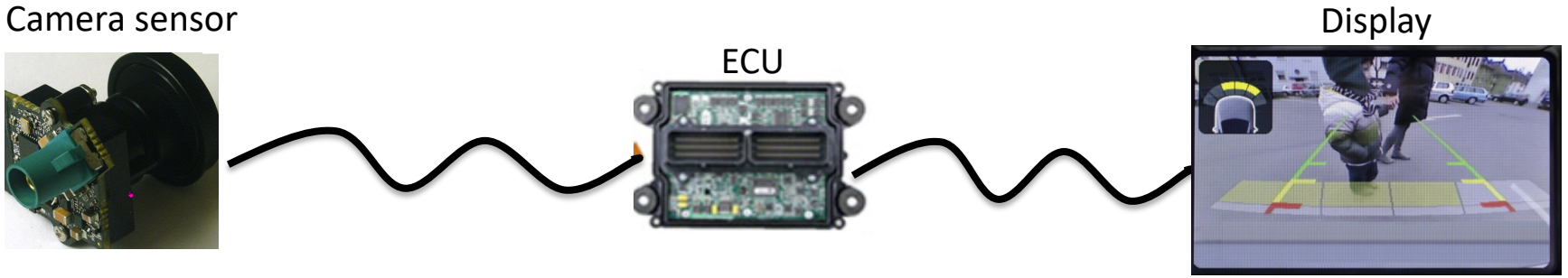
Challenges to be solved require: A-PHY + MIPI Protocols



Robust Automotive Long Reach Link	• PER = 10^{-19} : 1 packet error in ~10000 car-lifetimes • High Speed Downlink and aggregation to support **multiple** 4K cameras and displays • Asymmetric high speed link with fixed low latency ~6µs @G5
End to End Functional Safety	• Enabling Integration of devices using MIPI protocols over A-PHY in ASIL B or ASIL D Systems • A-PHY **and** Protocols (CSI-2, DSI-2) FuSa from Source to Sink
End to End Security	• Authentication; prevention of tampering (malicious and non-malicious) • High Definition Content Protection (HDCP) for display applications
Heterogeneous Interfaces	• Common support for multiple display protocols: DSI, Display Port, eDP, OpenLDI • Agnostic to source/sink PHY configuration : C-PHY, D-PHY, Lanes count

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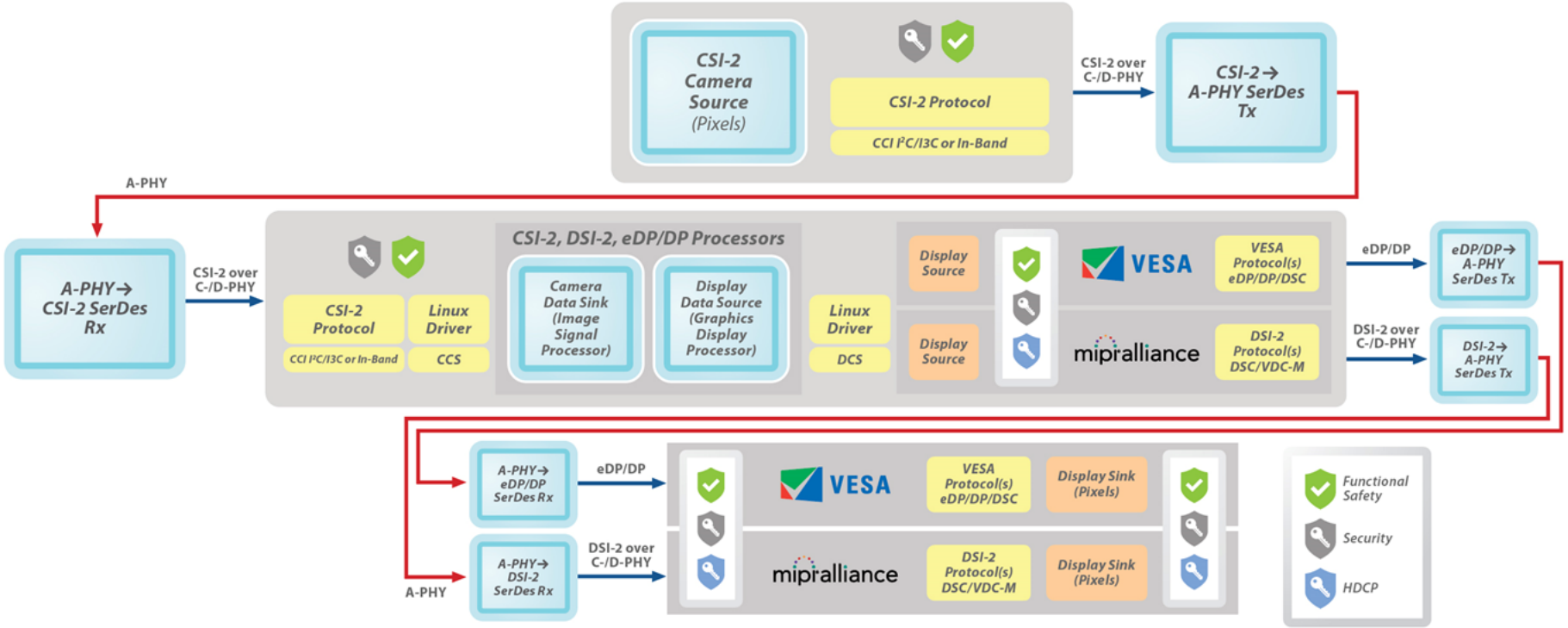
MASS: MIPI Automotive SerDes Solutions

A vision for End-to-End System



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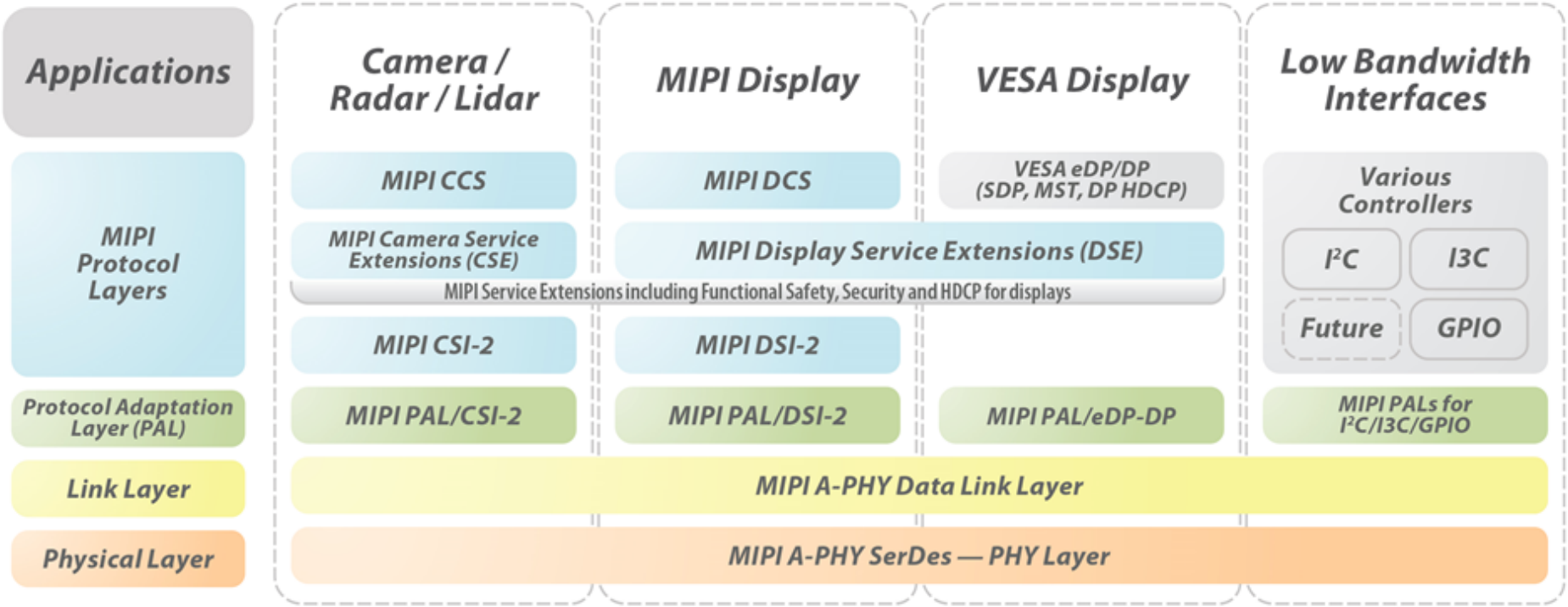
Automotive Protocol Stack-up Diagram



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MIPI A-PHY – Specification overview

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Gears and Profiles

- One Rate/line-code/modulation per Downlink Gear
- Single Uplink Gear
- Two Noise/Performance Profiles (with full inter-profile interoperability):
  - **Profile 1:** optimized for low cost/power implementations for the lower gears with lower Noise immunity and target PER of $<10^{-9}$
  - **Profile 2:** optimized for Vehicle Life-span, link robustness for all Gears with high noise immunity and target **PER of $<10^{-19}$**
- A-PHY Device supporting Gear N (N could be 1–5) shall support all lower gears.

Gear Data Rate	Modulation [One modulation per Gear]	Symbol Rate [GBaud]	Net Application Data Rate [Gbps]
G1 2 Gbps	NRZ-8b/10b	2	1.5
G2 4 Gbps	NRZ-8b/10b	4	3
G3 8 Gbps	PAM4	4	7.2
G4 12 Gbps	PAM8	4	10.8
G5 16 Gbps	PAM16	4	14.4
Uplink, All Gears 100Mbps	NRZ-8b/10b	0.1	0.055 (55Mbps)

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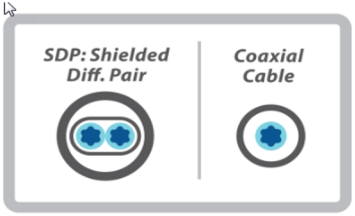
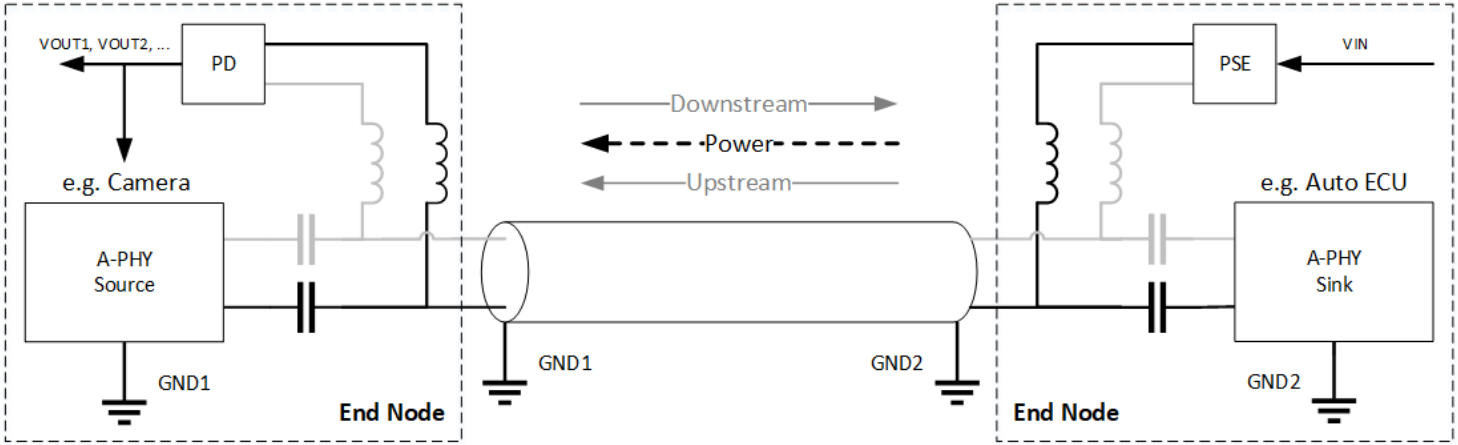
Interconnect Channel

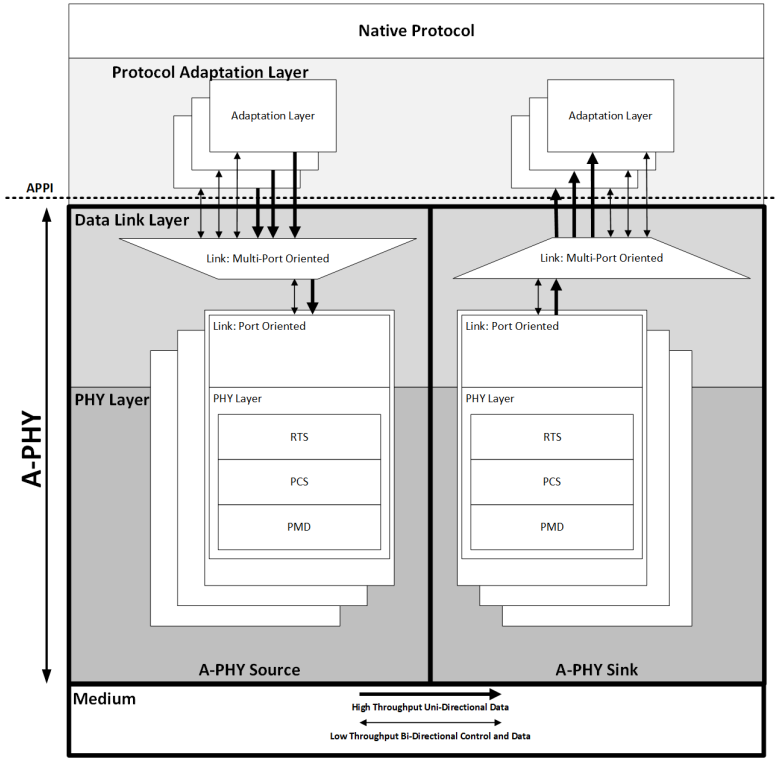
- A-PHY is a single lane, point-to-point, serial communication technology
- Support for multiple cable types – SDP/Coax
- Power over Cable support
- Up to 15m with 4 inline connectors





High Level Structure

- **Native Protocol**
  - e.g. MIPI CSI-2, MIPI DSI-2, I2C, GPIO
- **Protocol Adaptation Layer (PAL)**
  - Mapping to/from Native Protocol to A-Packet
- **APPI**
  - Interface between A-PHY Port and PAL
- **Data Link Layer**
  - Performs A-Packet scheduling, prioritization and forwarding
- **Physical Layer**
  - Encodes and decodes symbols extracted from A-Packets according to the modulation scheme used per Gear.
  - Modulated symbols are transmitted and received over the A-PHY interconnect according to the medium-dependent electrical specifications



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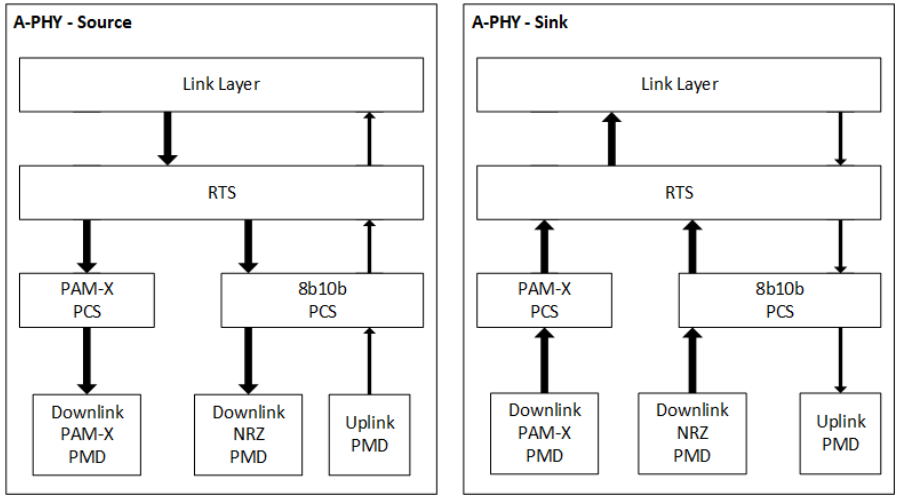
PHY Layer

- Unified structure to reduce complexity
- Shared 8B/10B PCS for G1/G2 and Uplink
- RTS Sub-Layer
  - Manage Data Pacing and buffering
  - Assign Message Counter (MC) and CRC
  - P2 - the retransmission process for A-Packets that are erroneous or that are not received
- PCS Sub-Layer
  - specifies the conversion of Data Link Layer A-Packets into PHY Symbols.
  - In P2, PCS also handles the JITC(*) Re-Training
- PMD Sub-Layer
  - Defines the electrical specifications and the physical medium



(*) JITC – Just In Time Cancelers (Cancellers that are used only when needed as channel changes)

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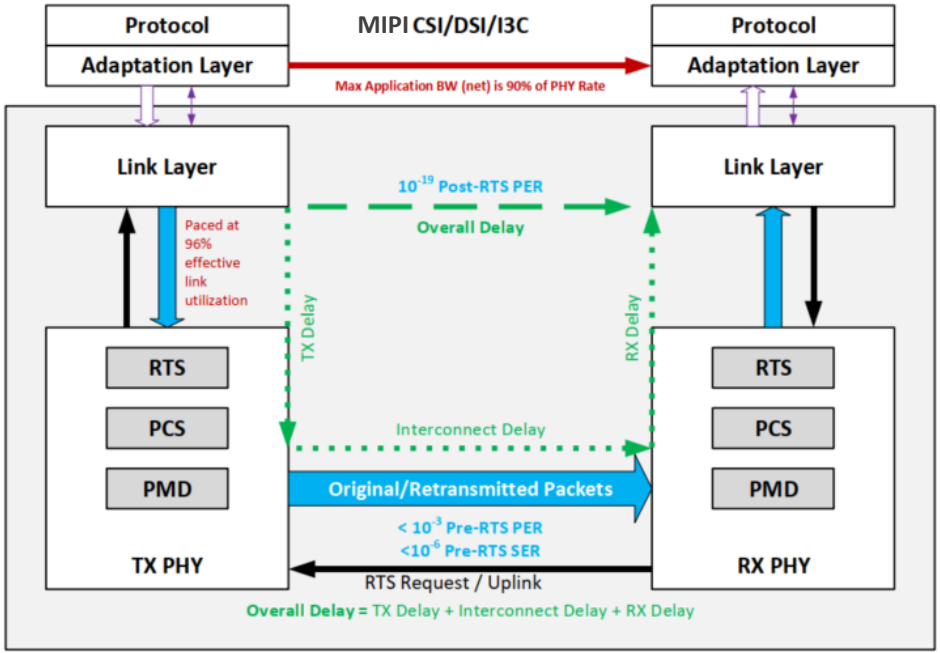
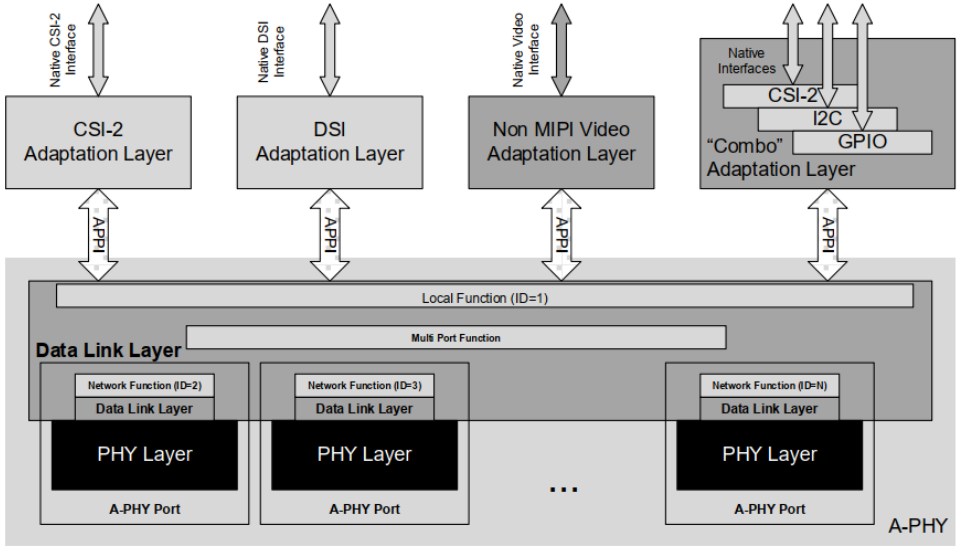
RTS - Time Bounded Local PHY Level Retransmission

- **Time Bounded**
  - Retransmission is attempted only within predefined "Overall Delay" (e.g. ~6µS @G5)
- **Local PHY Level**
  - Transparent to upper layers
  - Happens within a single A-PHY Hop
- **Dynamically Modulated**
  - Retransmitted packets has better error resistant data payload Sub-Constellation.
- **Highly Reliable**
  - **PER (Packet Error Rate) < 10^{-19}**
- **Highly Resilient**
  - Overcome Thousands symbols-long Error bursts
  - Multiple 10s of mVs, instantly attacking, NBI Peak.
- **Low Overhead**
  - Overall PHY + Link < 10% ➔ **90% Net Data rate**



Data Link Layer

- The A-PHY Data Link Layer is a protocol agnostic layer that performs scheduling, prioritization and forwarding of A-Packets.
- Each Protocol Adaptation Layer has at least one APPI connection to the A-PHY Data Link Layer.
- A-PHY Data Link Layer may be connected to multiple Protocols Adaptation Layers using a single Local Function.
- The A-PHY Data Link Layer may have a single A-PHY Network Function connected to it, or multiple A-PHY Network Functions



- The A-PHY Data Link Layer Enables A-Packet:
  - Forwarding
  - Prioritization
  - Duplication
  - Scheduling

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Functional Safety

- A-PHY packets are end-to-end protected as recommended in ISO-26262:2018:
  - CRC-32 for each packet, providing a Hamming-Distance of more than 3.
  - Message Counter that is 8 bits wide.
  - Timeout monitoring is fulfilled by the Keep-Alive function.
- The above measures are necessary to argue a high diagnostic coverage for a communication bus, per *Table D.6* in ISO 26262-5:2018
- All other functional safety features necessary in order to fulfil the required system-level safety goal with ASIL is expected to be managed by upper layers.

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Noise Immunity

- There is a major variance in the OEM EMC requirements, from those who aim for minimal noise immunity, to OEMs that apply stringent requirement to protect their system
- A-PHY two profiles provide two noise immunity levels, to accommodate this variance.
  - P1 has lower noise immunity, similar to other SERDES solutions and is applicable for G1 and G2 (optional G3)
  - P2 has very high noise immunity based on MIPI Alliance analysis of expected noise level for the car life-time period.
- MIPI conducted multiple tests in an independent labs evaluating the noise levels and shielding effect degradation after mechanical stress and aging
  - The results helped evaluate the different available technologies
  - The research continues as part of MIPI A-PHY SG activities

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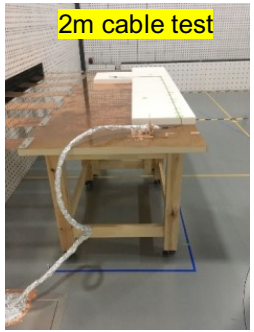
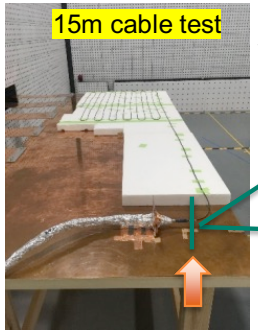
Characteristics of RF Ingress Test

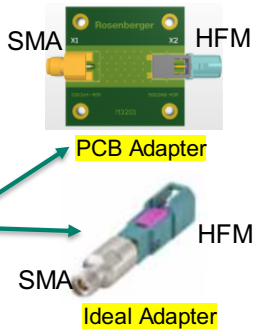
Test Conditions

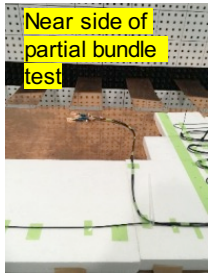
Cable: Two types of Dynamics Coax cables in length of 2m and 15m

Lab Conditions:



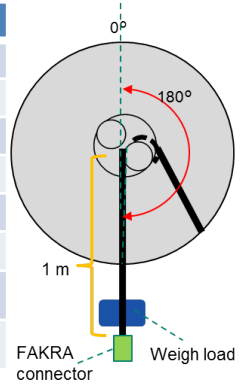




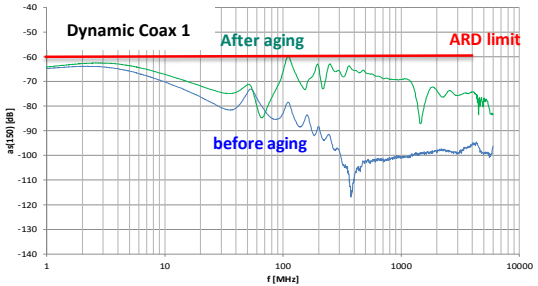


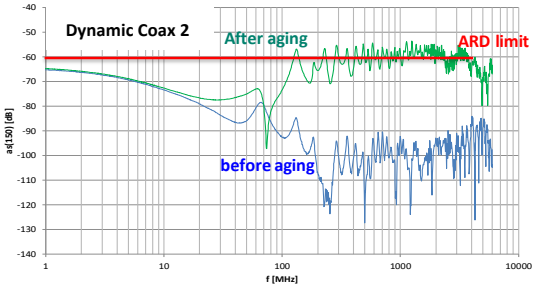
Bending Fatigue & Temperature Cycling Test

Mechanical condition	Bending angle	180°
	Bending diameter	60 mm
	Bending Speed	10 times/min
	Weight load	3 N (~0.3kgf)
Temperature condition	Temp. cycle	See below fig.
	Temp. range	-25~25~105°C
Total number of bending		36000 times
Total time		Roughly 72 hours



Screening Attenuation Test Result





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A-PHY Future Outlook

- MIPI is working on the upcoming MIPI A-PHY V1.1 release
- This is an incremental version to the A-PHY V1.0
- Main A-PHY V1.1 features
  - **Up to 32Gbps** throughput using Dual Lane Downlink support over STQ cables
  - Double Rate Uplink (DRU) with 125Mbps Uplink effective throughput
  - PAM-4 support for lower gears – Better noise immunity with lower working frequency enabling usage of lower costs cables and connectors
- Additional Protocol Adaptation Layers – 100Mbps ETH and I2S

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Concluding Thoughts

- *In-vehicle architecture is **rapidly evolving** . . .*
- *Increased focus on **surround sensor applications** for ADAS / autonomous driving . . . Best served by dedicated high-speed asymmetric interfaces from sensors to ECU.*
- *Standardization important for **economies of scale, lower cost & greater capabilities**.*
- *The native MIPI protocols (CSI-2, DSI-2, I3C, others, available in billions of devices) with **A-PHY deliver enormous benefit** to the automotive industry . . . performance, cost, noise immunity, and long-term EBOM reduction via elimination of interface bridges.*
- *The MIPI solution is being developed to **meet the broadest spectrum** of automotive industry needs . . . with anticipated SOP as early as 2024.*

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